

## **CHLORINATED HYDROCARBONS IN PELAGIC FORAGE FISHES AND SQUID OF THE SOUTHERN CALIFORNIA BIGHT**

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Keywords: total DDT, total PCB, bioaccumulation, southern California

### **INTRODUCTION**

Large quantities of the chlorinated hydrocarbons dichlorodiphenyltrichloroethane (total DDT) and polychlorinated biphenyls (total PCB) have been historically discharged to the southern California Bight (SCB). An estimated 41.5 metric tons (mt) of total DDT and 55.5 mt of total PCB have been discharged to the SCB since 1971 (Schiff, et. al. 2001). Most of these chlorinated hydrocarbons emanated from the Montrose Chemical Corporation, formerly the worlds largest manufacturer of total DDT, and was discharged through the sanitary sewer system ocean outfall (Stull 1995). Since 1970 when the use of total DDT was banned and Montrose halted production, discharges from the ocean outfalls in the SCB has dramatically decreased and chlorinated hydrocarbon emissions are presently nondetectable. However, the legacy of this contamination is still observed in the SCB. The highest sediment concentrations are found near Palos Verdes on the Los Angeles margin and more than 82% of the ocean floor in the SCB has sediments with measurable total DDT and/or total PCB (Schiff 2000). An estimated 96% of the Pacific sanddab (*Citharichthys sordidus*), the most common flatfish on the SCB shelf, is contaminated with total DDT and/or total PCB (Schiff and Allen 2000). Reproductive impairment due to total DDT and/or total PCB was observed in white croaker (*Genyonemus lineatus*) (Cross and Hose 1988). Health-risk advisories to warn anglers still exist along many kilometers of the southern California coastline for several species, including white croaker.

While contaminant pathways to sediment-associated biota are well documented, contaminant pathways to higher-level predators are still uncertain. Little data exists in pelagic forage fishes and squid that might serve as pathways to mammals and seabirds. Yet concentrations of total DDT and total PCB in 2000 still averaged 150 µg/kg in the blubber of marine mammals such as California sea lions (Kannan et. al. 2004) and reproductive failures in bald eagles on the SCB Channel Islands continues (D. Witting, NOAA, NMFS, Southwest Regional Office, Long Beach, CA, pers. com. May 13, 2006). The primary objective of this study was to assess the extent and magnitude of total DDT and total PCB in pelagic forage fishes within the SCB. This goal will be addressed by answering two basic questions: 1) What percent of the pelagic forage fish biomass exceeds wildlife risk screening values?; 2) Are there geographic patterns in the concentration of total DDT, total PCB, or the percentage of biomass that exceeds thresholds of concern? These data can then be used for determining potential pathways to higher predators such as marine mammals and birds.

## METHODS

Pelagic forage fish and squid were collected between July 2003 and Feb 2004 at local commercial fishing ports along the southern California coast from Ventura to San Diego. Both commercial landing markets and bait receivers were randomly targeted for sampling. Fishing location was determined from landing receipts or directly from the fishing captain or bait receiver tenders. Fishing location was typically provided as California Department of Fish and Game (CDFG) fishing block, a number identifying a 16 x 16 km (10 x 10 mi) block encompassing a 260 km<sup>2</sup> (100 mi<sup>2</sup>) area within the SCB.

Species selection was based on two criteria: 1) species comprising the greatest biomass in the SCB; and 2) favored prey items by either marine birds or mammals. The species selected for contaminant analysis were northern anchovy, Pacific sardine, Pacific chub mackerel, and California market squid. Samplers systematically sampled individuals from fish bins throughout an entire fishing vessel load during the offloading process. Individuals were rinsed with deionized water, wrapped in foil, labeled, and frozen until sample processing.

The sampling design included stratifying the SCB into four geographic regions including: 1) north coast; 2) central coast; 3) south coast; and 4) offshore islands. Ten whole fish composite samples per species per region were targeted, except for Pacific chub mackerel (three samples per region), for a total of 160 sample composites. Samples were distributed as evenly as possible over summer and non-summer months of the sampling period. Target analytes included total DDT (*ortho*- and *para*- isomers of DDT and its degradation products DDE and DDD) and 41 PCB congeners (18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, 206).

The wildlife risk screening values used to assess predator risk were from the National Academy of Science and Environment Canada (1997, 1998). The screening value for total DDT was 14.0 µg/kg ww and that for PCB was 0.79 ng TEQ/kg.

## RESULTS

Tissue concentrations differed among species (Figure 1). Northern anchovy had the highest biomass-weighted average concentrations of total DDT ( $61 \pm 38$  µg/kg ww). All but one of the northern anchovy samples had detectable quantities of total DDT and these concentrations ranged from 3 to 135 µg/kg ww. California market squid had the lowest biomass-weighted average concentration of total DDT ( $0.8 \pm 1.2$  µg/kg ww). Fifty percent of California market squid samples had nondetectable concentrations. Pacific sardine and Pacific chub mackerel had intermediate biomass-weighted average concentrations of total DDT ( $34 \pm 29$  and  $41 \pm 40$  µg/kg ww, respectively). Both species also ranged in total DDT concentration from 3 to >100 µg/kg ww with only a single nondetectable sample (for Pacific sardine). Pacific chub mackerel had the maximum total DDT concentration of all three species (141 µg/kg ww). The distribution of total PCB concentrations between species mimicked total DDT concentrations, but was lower by approximately one order of magnitude. For example, the biomass weighted average total PCB concentration in northern anchovy was  $3 \pm 5$  µg/kg ww.

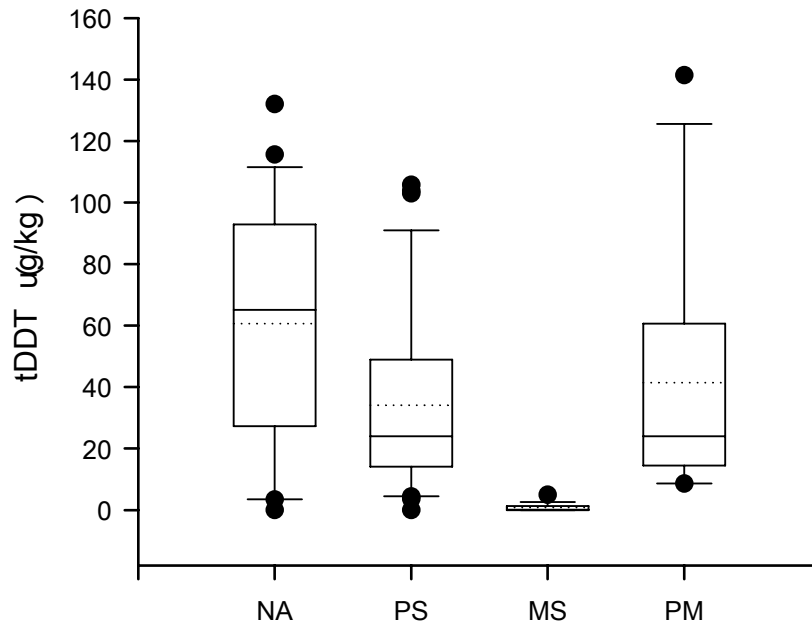
Approximately 99% of all commercial landings of northern anchovy in the SCB exceeded wildlife-risk screening values for total DDT during this study. Approximately 86% of the Pacific sardine and 33% of the Pacific chub mackerel commercial landings also exceeded the total DDT screening values during this study. None of the California market squid landings exceeded the wildlife risk screening value for total DDT. The extent of total PCB exceedence of wildlife risk screening values (as TEQs) was much less. Less than 1% of the commercial landings for Pacific chub mackerel exceeded wildlife-risk screening values for birds during this study. None of the other species exceeded the PCB risk screening values for either birds or mammals.

## DISCUSSION

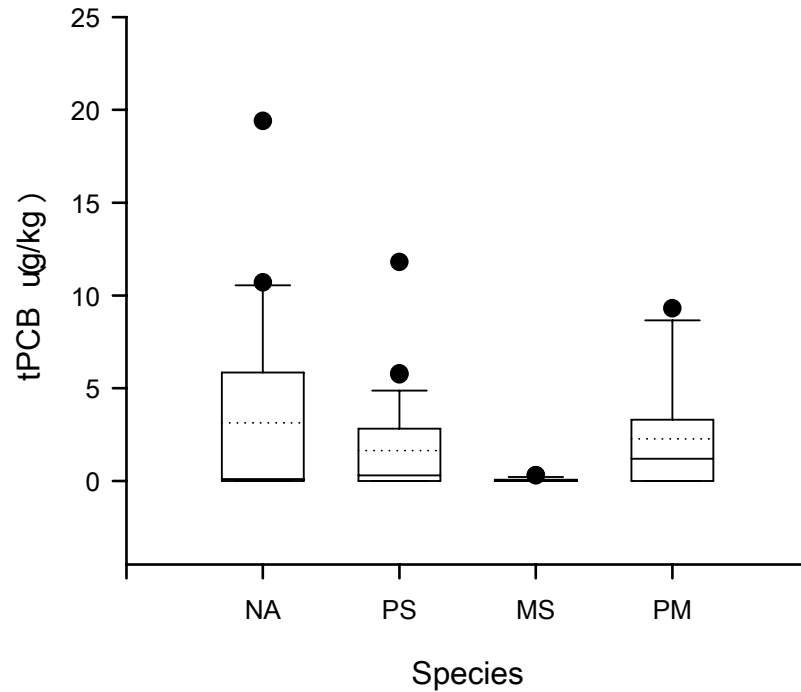
Despite the reduction in the discharge of total DDT and total PCB in the SCB over the last 35 years, a large fraction of pelagic biomass appears to be affected by total DDT. The extent of bioaccumulation examined herein was widespread with multiple species; sardines, anchovies, and mackerel accumulated measurable total DDT and total PCB throughout virtually all of the landings in the SCB. Moreover, the accumulation of total DDT, based upon wildlife risk screening values, was at levels that represented a potential risk to higher order predators such as marine birds and mammals.

There were several factors that could cause or contribute to the bioaccumulation observed in this study. One factor could be equilibrium partitioning between the concentrations in the water column and lipid reservoirs in the fish because a strong correlation was observed between tissue concentrations and fish lipid content during this study. A second factor could be life history strategy including diet and age. For example, squid were the shortest lived species (< 1 yr) we examined and they also had the lowest tissue concentrations. In contrast, Pacific sardine were the longest lived (3 – 7 yr) and had the greatest tissue concentrations. A third factor that could affect tissue concentration is fish mobility and migration. Many of these species migrate long distances and it is unclear where the exposure to total DDT and total PCB occurred. However, the greatest tissue concentrations generally occurred in the central portion of the SCB where the greatest sediment and water column concentrations of total DDT and total PCB also occur (Schiff 2000, Zeng et. al. 2005).

a) Total DDT



b) Total PCB



**Figure 1. Box plots of a) total DDT and b) total PCB in pelagic forage fish and squid whole fish composites sampled from southern California commercial fish markets and bait receivers during July 2003 – February 2004. (NA=northern anchovy (n = 24);**

**PS=Pacific sardine (n = 34); MS=California market squid (n = 28); PM=Pacific chub mackerel (n = 13)).**

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